

CLAIMS:

1. A method of producing vacuum ultraviolet light, comprising the steps of:

maintaining a gas mixture containing a rare gas and a halogen in a chamber so that at least a portion of said gas mixture is disposed in an emission region between a pair of electrodes at a selected pressure;

applying electrical potential between said electrodes so as to form an electrical discharge in said emission region between said electrodes and apply power to the gases in said emission region at a selected power density to thereby form excimers selected from the group consisting of RGZ^* and Z_2^* where RG represents a rare gas and Z represents a halogen;

maintaining a concentration of said halogen in the chamber substantially equal to an optimum concentration which maximizes ultraviolet emission from said excimers at said selected pressure and power density.

2. The method as claimed in claim 1, further comprising the step of passing said gas mixture through said chamber at a selected flow rate, wherein said gas mixture passed through said chamber contains an amount of said halogen selected substantially equal to an optimum amount which maximizes said ultraviolet emissions at said selected flow rate, pressure and power density.

3. The method as claimed in claim 2, wherein said selected flow rate is at least about 30 sccm.

4. The method as claimed in claim 1, wherein said selected pressure is at least about 0.3 bar.

5. The method as claimed in claim 1, wherein said power density in said emission region is at least about 20 kW/cm³.

6. The method as claimed in claim 1 wherein said excimers are of the form Z_2^* .

7. The method as claimed in claim 6 wherein said gas mixture includes F_2 and said excimers are F_2^* .

8. The method as claimed in claim 1, wherein said gas mixture includes a rare gas and a halogen and said excimers are of the form RGZ^* .

9. The method as claimed in claim 8 wherein said gas mixture includes argon and fluorine and said excimers are ArF^* .

10. The method as claimed in claim 1, wherein said concentration of said halogen in said chamber is between about 1 and about 5%.

11. The method as claimed in claim 1, wherein said concentration of said halogen in said chamber is about 2%.

12. The method as claimed in claim 1, wherein said step of applying electrical potential is performed by applying an alternating potential having a frequency of at least about 100 KHz.

13. The method as claimed in claim 1, wherein said electrodes are needle shaped such that they taper to substantially a point.

14. The method as claimed in claim 1, wherein said electrodes have a rounded shape such that the ends are convexly shaped and are substantially rounded.

15. An apparatus for producing vacuum ultraviolet light, comprised of:

a chamber containing two electrodes defining an emission region therebetween;

a gas at a pressure within said chamber, said gas including a halogen and a rare gas such that the mixture is capable of forming an excimer of the form RGZ^* or Z_2^* where RG represents a rare gas and Z represents halogen; and

a power source for providing electrical potential to said electrodes such that an electrical discharge is formed in said emission region between said electrodes, said power source being adapted to provide a power density between said

29

electrodes, said gas containing an amount of said halogen such that the concentration of said halogen in said emission region is substantially equal to an optimum concentration which maximizes ultraviolet emissions from said excimers of the form RGZ* at said pressure and said power density.

16. The apparatus as claimed in claim 15, further comprising a gas source, said chamber having an inlet opening connected to said gas source and an outlet opening, said gas source, said inlet opening and said outlet opening being adapted to pass said gas through said chamber at a flow rate, said gas containing an amount of said halogen substantially equal to an optimum amount which maximizes said ultraviolet emissions at said flow rate, said pressure and said power density.

17. The apparatus as claimed in claim 16, wherein said flow rate is at least about 30 sccm.

18. The apparatus as claimed in claim 15, wherein said pressure is at least about 0.3 bar.

19. The apparatus as claimed in claim 15, wherein said power density in said emission region is at least about 20 kW/cm³.

20. The apparatus as claimed in claim 15, wherein said concentration of said halogen in said chamber is between about 1 and about 5%.

21. The apparatus as claimed in claim 20, wherein said concentration of said halogen in said chamber is about 2%.

22. The apparatus as claimed in claim 15, wherein said power source is adapted to provide an alternating potential having a frequency of at least about 100 KHz.

23. The apparatus as claimed in claim 15, wherein said electrodes are substantially coaxial with one another and each said electrode is needle shaped such that such electrode tapers to a point adjacent said emission region.

30

24. The apparatus as claimed in claim 15, wherein said electrodes have a rounded shape such that the ends are convexly shaped and are substantially rounded.

25. The apparatus as claimed in claim 15, wherein at least a portion of said chamber is transparent to said ultraviolet emissions.

26. A method of producing vacuum ultraviolet light, comprising the steps of:

maintaining a gas containing a rare gas in a chamber so that at least a portion of said gas is disposed in an emission region between a pair of electrodes;

applying electrical potential between said electrodes so as to form an electrical discharge in said emission region between said electrodes and apply power to said gas in said emission region, wherein a plasma is formed in said emission region such that said plasma emits ultraviolet light by a radiative process including transition of excimers of the form RG_2^* to a lower-energy state; and

maintaining said plasma at a temperature such that the average kinetic energy of gas particles in said discharge region is such that there is only a negligibly small equilibrium population of vibrationally highly excited RG_2^* molecules with vibration energy levels close to the binding energy of the RG_2^* excimer.

27. The method as claimed in claim 26, wherein said step of maintaining said temperature in said emission region is performed so that said average kinetic energy is less than the vibrational excitation energy of said excimers.

28. The method as claimed in claim 26, further comprising the step of passing said gas through said chamber at a flow rate of at least about 30 sccm.

29. The method as claimed in claim 26, further comprising the step of maintaining said gas in said chamber at a pressure of at least about 0.3 bar.

31
31. The method as claimed in claim 26, wherein said electrical potential is applied so as to provide a power density of between about 0.1 and about 20 kW/cm³ in said emission region.

5 32. The method as claimed in claim 26 wherein said rare gas is selected from the group consisting of He, Ne, Kr, Ar, Xe and mixtures thereof.

33. The method as claimed in claim 26, wherein said gas includes Ne and H₂ and said radiative process includes energy
10 transfer from Ne₂^{*} excimers to hydrogen.

34. The method as claimed in claim 33, wherein said gas has a partial pressure of Ne of about 300 to about 1000 mbars and a hydrogen partial pressure of about 0.1 to about 15 mbars.

15 35. The method as claimed in claim 26, wherein said step of applying said electrical potential is performed so as to provide a power density per unit surface area of each of said electrodes of about 1 W/mm² or less.

20 36. The method as claimed in claim 45, wherein said electrodes have substantially spheroidal surfaces disposed adjacent said emission region.

37. An apparatus for producing vacuum ultraviolet light, comprised of:

25 a chamber containing two electrodes defining an emission region therebetween;

gas within said chamber, said gas being comprised of a rare gas that will form an excimer of the form RG₂^{*}, where RG represents said rare gas; and

30 a power source for providing electrical potential to said electrodes such that an electrical discharge is formed in said emission region between said electrodes, wherein a plasma is formed in said emission region such that said plasma emits ultraviolet light by a radiative process including transition of excimers of the form RG₂^{*} to a lower energy state, and a

32

temperature is maintained in said emission region such that said gas is at a temperature such that the average kinetic energy of gas particles in said discharge region is such that there is only a negligibly small equilibrium population of
5 vibrationally highly excited RG_2^* molecules with vibration energy levels close to the binding energy of the RG_2^* excimer.

38. The apparatus as claimed in claim 37, wherein said temperature in said emission region is maintained such that said average kinetic energy is less than the vibrational
10 excitation energy of said excimers.

39. The apparatus as claimed in claim 37, further comprising a gas source, said chamber having an inlet opening connected to said gas source and an outlet opening, said gas source, said inlet opening and said outlet opening being
15 adapted to pass said gas through said chamber at a flow rate.

40. The apparatus as claimed in claim 37, wherein said gas in said chamber is at a pressure of at least about 0.3 bar.

41. The apparatus as claimed in claim 37, wherein said
20 power source and said electrodes are arranged to apply said electrical potential at a power density per unit area of each said electrode of about 1 W/mm² or less.

42. The apparatus as claimed in claim 37 wherein each of said electrodes has a surface having an area of at least about
25 0.75 mm² confronting said emission region.

43. The apparatus as claimed in claim 37, wherein each of said electrodes has a substantially spheroidal surface confronting said emission region.